Back-to-back high p_T hadron correlations with respect to the reaction plane

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In high energy heavy-ion collisions, a high density system consisting of deconfined quarks and gluons is expected to be created [1]. Energetic partons, resulting from initial hard scatterings, are predicted to lose energy by induced gluon radiation when propagating through matter [2]. This energy loss is expected to depend strongly on the color charge density of the system and the traversed path length of the outgoing parton.

In non-central heavy-ion collisions the geometrical overlap region has an almond shape in the transverse plane with its short axis in the reaction plane. Depending on the emission azimuthal angle, partons traversing this system, on average, experience different path lengths and therefore different energy loss. It leads to azimuthal anisotropy in high p_t particle production, characterized by the second harmonic in the particle azimuthal distribution with respect to the reaction plane, $v_2 = \langle\cos(2\Delta\phi)\rangle$, and to the dependence of the high p_t two-particle azimuthal correlations on the orientation of the pair with respect to the reaction plane.

At high transverse momenta, two-particle distributions in the relative azimuthal angle measured in $p+p$ and Au+Au collisions at RHIC exhibit a jet-like correlation characterized by the peaks at $\Delta\phi = 0$ (near-side correlations) and at $\Delta\phi = \pi$ (back-to-back). The back-to-back peak is found to be strongly suppressed in central Au+Au collisions [3]. In an energy loss scenario the suppression should depend on the relative orientation of the back-to-back pair with respect to the reaction plane. In this analysis of STAR data obtained from Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV, we select *trigger* particles with $4 < p_t^{\rm trig} < 6$ GeV/c emitted in the direction of the event plane angle Ψ_2 (in-plane, $|\phi^{\rm trig} - \Psi_2| < \pi/4$ and $|\phi^{\rm trig} - \Psi_2| > 3\pi/4$) and perpendicular to it (out-of-plane, $\pi/4 < |\phi^{\rm trig} - \Psi_2| < 3\pi/4$). The trigger particles are paired with *associated* particles with $2 < p_t < p_t^{\rm trig}$.

In the upper panel of Fig. 1 we show the azimuthal distributions of associated particles for in-plane (squares) and out-of-plane (circles) trigger particles in midcentral Au+Au collisions. The in-plane and out-of-plane two-particle azimuthal distributions exhibit strong elliptic flow pattern, which is given by [4]:

$$\frac{dn^{\,in}_{\,out}}{d\Delta\phi} \propto 1 + 2v_2^{\rm assoc}\frac{\pi v_2^{\rm trig} \pm 2\langle\cos 2\Delta\Psi\rangle}{\pi \pm 4v_2^{\rm trig}\langle\cos 2\Delta\Psi\rangle}\cos 2\Delta\phi, \quad (1)$$

where $v_2^{\rm assoc}$ and $v_2^{\rm trig}$ are the elliptic flow of the associated and trigger particles, respectively, and $\langle\cos 2\Delta\Psi\rangle$ is the reaction plane resolution. For the given centrality $\langle\cos 2\Delta\Psi\rangle = 0.70$; $v_2^{\rm assoc} = 0.2$, and $v_2^{\rm trig} = 0.18$ measured via a reaction plane method. The distributions were fit to $B(dn^{\rm in/out}/d\Delta\phi)$ in the region $0.75 < |\Delta\phi| < 2.24$ rad, with B as the only free parameter, to determine the amount of background. We observe a strong excess of two-particle correlations over elliptic flow in the region $|\Delta\phi| < 0.75$ for both in-plane and out-of-plane distributions, characteristic of near-side intra-jet correlations. In the region around $\Delta\phi = \pi$, we observe an excess for the in-plane distribution, but no excess is found for the out-of-plane distribution. This is better illustrated in the lower panel of Fig. 1, where we show the flow-subtracted in-plane and out-of-plane distributions compared to that measured in $p+p$ collisions. The near-side jet-like correlations measured in Au+Au are similar to those measured in $p+p$ collisions. The back-to-back (around $\Delta\phi = \pi$) correlations measured in Au+Au collisions for in-plane trigger particles are suppressed compared to $p+p$, and even more suppressed for the out-of-plane trigger particles. These results strongly support jet-quenching scenario and provide information on the path length dependence of the energy loss in a dense medium created at RHIC.

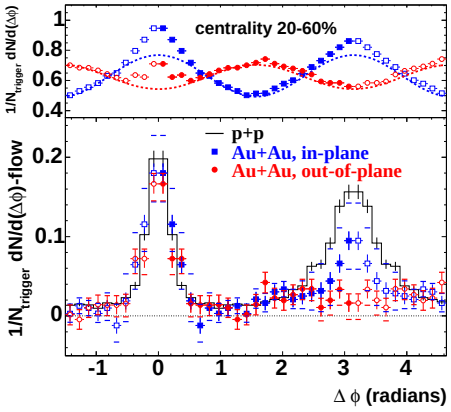

FIG. 1: Upper panel: Azimuthal distributions of associated particles for trigger particles in-plane (squares) and out-of-plane (circles) for Au+Au collisions at centrality 20-60%. Open symbols are reflections of solid symbols around $\Delta\phi = 0$ and $\Delta\phi = \pi$. Elliptic flow contribution is shown by dashed lines. Lower panel: Elliptic flow subtracted distributions and that measured in p+p collisions (histogram).

[1] J. W. Harris and B. Muller, Ann. Rev. Nucl. Part. Sci. **46**, 71 (1996).

[2] R. Baier, D. Schiff, and B. G. Zakharov, Ann. Rev. Nucl. Part. Sci. **50**, 37 (2000).

[3] C. Adler et al. (STAR), Phys. Rev. Lett. **90**, 082302 (2003).

[4] J. Bielcikova, S. Esumi, K. Filimonov, S. Voloshin, and J. P. Wurm, Phys. Rev. **C69**, 021901 (2004).